## THE STUDY OF STELLAR EVOLUTION.[1]

WE are becoming so accustomed to fresh proofs of Prof. Hale's versatility and thoroughness that the appearance of this volume hardly strikes us as being so remarkable as it would have done had another written it, but even this fact cannot detract from the feelings of wonder and admiration which are forced upon us as we peruse the contents.

It should be noted that this work is not *a* study, but is an account of *the* study, of stellar evolution, telling us of the methods and apparatus applied in attacking the various problems, and how far such means have already been successful. It was at first intended as a handbook to the Yerkes Observatory, but the removal of the author to the new solar observatory at Mount Wilson, with its new equipment and newer methods, rendered it advisable that the scope of the work should be widened.

Prof. Hale looks upon the evolution of stellar systems, not as an entity, but as a part of the general scheme of evolution which began with the Beginning and at present ends in the social systems which govern man, and it is in this philosophical spirit that he introduces his subject in the first chapter. The great differences between the old and the new astronomy are then pointed out, with reference to the changes introduced by the application of photography to the study of astronomy, and the consequent importance of the methods of reduction which have to be applied to the photographic results.

The sun is then discussed as a typical star, and Prof. Hale answers a question which is continually being asked by persons who are not thoroughly familiar with solar work. Why at a solar observatory, such as Mount Wilson, are time and opportunities spent in studying stars and other masses outside the solar system? Why pay attention to those far-away systems which can never, within comprehensible time, exert any influence on terrestrial conditions? The author expunges all doubt in his reply to these questions. Just as the biologist, by studying the lower forms of life, discovers the laws which regulate the life and being of man, so must the solar physicist appeal to those other stars, of earlier and later birth, in order to comprehend solar phenomena.

Those who heard Prof. Hale's evening lecture at the Royal Astronomical Society in 1905 will recognise the sentiment of the succeeding chapters, in which, while describing various instruments, he insists upon the useful work that may be accomplished with very modest equipments, and shows that, if the worker only gives earnest consideration to the choice of a definite research, he may find that his smaller instruments will prove equally efficient with the larger ones. Among the beautiful full-page illustrations at the end of the volume there are a number illustrating this point.

Chapters dealing with the reflecting telescope and the principles of spectrum analysis, in which the work of Herschel, Fraunhofer, Kirchhoff, Huggins, Secchi, Lockyer, Janssen, and others is briefly described, bring the history of these subjects up to date, and lead to a description of grating spectroscopes, their history and manufacture. In this regard it is gratifying to be assured that Michelson has completed a ruling-machine, with an almost perfect screw, designed to rule 14-inch gratings, and has already completed gratings of ten and twelve inches. By constructing a machine with four screws he further hopes to reduce the ruling errors to one-fourth the amount produced in a single-screw machine.

After discussing the phenomena of the sun's surface and surroundings, and the historical discoveries concerning them, the author proceeds to a description of the evolution of the photo-spectroheliograph, in which he has played so great a part. He also emphasises the point that the explanation of the results offered in this chapter is merely an hypothesis which future researches may modify, and refers to the anomalous-dispersion explanation of Julius as one of the possible alternatives.

The perusal of chapter xii. leaves us with the ardent desire that British authorities and capitalists would see eye-to-eye with their American confrères as to the fundamental necessity of fostering scientific work, for Prof. Hale here describes the foundation, equipment and work of the Yerkes Observatory. Here, as in other parts of the book, the author strongly insists upon the necessity for an equipment capable of undertaking the concurrent study of the correlated solar, stellar, and terrestrial phenomena.

Notwithstanding the dictum of Newton and the experiments of Piazzi Smith and others, the question of the advantage of high altitudes for solar work has only become acute during the last decade or so, and no one is much better qualified than Prof. Hale to discuss this question. It is therefore with interest that we read the chapter dealing with this subject, in which he shows conclusively that altitude alone is not necessarily advantageous. Many of the higher peaks surrounding Mount Wilson have been proved to be unsuitable for solar work, whilst the author's experiences of Mount Etna, in July, 1894, were not of the kind calculated to make him regard it as an ideal site from which to attempt the photography of the corona without waiting for a total eclipse. Mount Hamilton, notwithstanding its glorious night "seeing," is said to be unsuitable for solar work on account of the atmospheric movements, adverse to good solar definition, set up by the intensely heated, bare rock which forms the slopes immediately surrounding the summit.

In chapter xiv. Prof. Hale describes the Mount Wilson site, and, from his experience there, defines five specific requirements for a site to be suitable for the prosecution of solar research and its necessary adjunct, the study of stellar evolution. After describing the Snow telescope and discussing the uses of spectroheliograph plates, the author proceeds to the study of sun-spots, and in this chapter we find one of the strongest arguments possible for the inclusion in a solar physics observatory equipment of the apparatus necessary for the correlated study of terrestrial spectroscopy and similar work. Prof. Hale has just previously described the numerous pieces of apparatus fitted up, ready for instant use, in the spectroscopic laboratory, and, speaking of the powerful magnet used to produce the Zeeman effect, he says:—"It is not a question here of detecting magnetic phenomena in the sun, since most careful study has not revealed any evidence of solar magnetic fields capable of affecting the appearance of spectral lines." Yet quite recently, since the above statement was penned, he has published results (NATURE, August 20, No. 2025, p. 369) which strongly suggest that the Zeeman effect, or something which produces similar phenomena, is *en évidence* in the sun-spot spectrum!

A chapter on stellar temperatures follows, and in describing the apparatus which has been used in the attempts to measure the stellar heat radiation directly, the author gives some interesting data illustrating the extreme delicacy of the apparatus with which Nichols, working at the Yerkes Observatory in 1898 and 1900,

[1] "The Study of Stellar Evolution; an Account of Some Recent Method of Astrophysical Research." By Prof. George Ellery Hale. (The Decennia: Publications, second series, vol. x.) Pp. xi+252; with 104 plates. (Chicago The University of Chicago Press; London: Wm. Wesley and Son, 1908.) Price 16*s*. 6*d*. net.

"Populäre Astrophysik." By Dr. J. Scheiner. Pp. vi+718; 30 plates. Leipzig and Berlin: B. G. Teubner, 1908.) Price 12 marks.

was able to detect the heat radiations received from Arcturus and Vega. The former was found to send us heat equivalent to that given by a candle about six miles away, if there were no absorption by the atmosphere, and Vega less than half that amount.

Following a chapter devoted to the nebular hypothesis we find a discourse on stellar development, and some interesting points are made concerning the various stellar classifications in the light of recent research. For example, Lockyer's temperature classification has been criticised on the ground that the observed changes of intensity of stellar lines might be produced by an indeterminate combination of electrical and temperature action. This has been recognised and reiterated by the author of the classification, who accepts the changes, whatever be their cause, as a basis on which a working hypothesis might be erected. But now we find Prof. Hale writing to the effect that the results obtained in the Mount Wilson laboratory imitation of sun-spot phenomena "seem to favour the view that a temperature classification of the stars, on the basis of the relative intensities of lines, is perfectly possible." In these experiments all electrical phenomena were excluded, but the above statement is not made unreservedly, as shown in the subsequent discussion of the meteoritic hypothesis. The work with the new 60-inch reflector at Mount Wilson, it is hoped, will provide a great deal of information respecting the fainter stars which has hitherto not been obtained.

In dealing with the meteoritic and planetesimal hypotheses, Prof. Hale directs special attention to the outstanding uncertainties respecting the transitional stage, nebula to star, and urges the importance of directing special attention to nebulæ by obtaining photographs of their structures and spectra; this research can only prove fruitful if the persistent prosecution of correlated laboratory experiments is carried out concurrently.

Discussing the question of the variation of the heat received from the sun, the author points out how small an amount of definite measurement has yet been undertaken, and urges that other observatories, in other regions of the earth, should cooperate in the bolographic work.

Kodaikanal, where the dry season corresponds with the wet season in South California, and an Australian station are suggested as localities in which the observations might be profitably inaugurated.

The importance of active cooperation between solar and meteorological observers, such as has of late years been instituted by the International Commission, is also emphasised.

The concluding three chapters (xxiii.–xxv.) are essentially of general interest. In the first the author describes at some length the making of the 60-inch reflector by Ritchey in the Mount Wilson workshops (Pasadena), and illustrations of the process are to be found among the plates. Then some possibilities of new instruments, *e.g.* the 100-inch reflector now under construction, are reviewed, and in the final chapter warm encouragement is given to the amateur observer. This embodies a series of hints on fitting up instruments, and, coming from a master who commenced his far-reaching studies with home-made instruments, they should be especially welcome, as they are essentially practical.

The printing and general get-up of the volume are of the high order one is accustomed to expect from the Chicago University Press, and the 104 full-page reproductions of actual photographs, which are bound up at the end, form by far the finest collection of general astronomical pictures ever yet published in a single volume.

In Prof. Scheiner's book we have a more conventional treatment of the subject of astrophysics, in which, in two parts, the whole subject is discussed under the customary headings and in popular terminology. Thus in the first section of part i. we find simple explanations of the fundamental principles underlying the methods employed, such as those of refraction, reflection, polarisation and dispersion of light, and the capacity and psychophysiological action of the eye considered as the final instrument on which the interpretation of all the phenomena depends to so large an extent.

In the following section the specific instruments are described, and the construction and adjustments of the spectroscope are expounded at length. The determination of absolute wave-lengths introduces us to the principles underlying the employment of the grating, and to the work of Kirchhoff, Doppler, Zeeman, and other pioneers in spectroscopic research.

The discussion of the spectra of elements is interpolated with data, such as the relationships of the spectra to the element's position in the periodic system, which should prove valuable for reference.

Photometry forms the subject of section iv., and the student should find helpful the descriptions and illustrations of the various instruments, and the discussion of the psychophysical actions which have to be accounted for in performing the reductions. The uncertainty which still attaches to the results obtained from attempts to measure the solar heat radiations is discussed in a brief chapter, and is well illustrated by a tabulated statement of the values derived for the solar constant by the various observers from Pouillet in 1837 to the author in 1902; the values range from 1·7 to 3·4 gr. cals., the lowest having been obtained by Vallot in 1896, and the highest by Crova and Hansky in 1897.

The four chapters which bring the first part of the book to a conclusion deal with the application of photography to astronomical work, and so much has already been written about the subject that there is but little new matter for the author to expound; but the instruments are clearly described and their various functions explained, the matter in the text being well illustrated by figures.

In eleven chapters (xviii.–xxviii.), the second part of the book deals with the results obtained from the employment of the instruments and methods previously described. The various solar phenomena, the surface appearance and physical characteristics of the moon and planets, and the results obtained from observations of comets and the zodiacal light are expounded at some length, and are illustrated by drawings and photographs in the text. These figures are generally good, but it is a pity that the drawings of several features, such as the Martian surface and the intensified lines of sun-spot spectra, could not have been supplemented by some of the excellent photographs now obtainable.

Chapter xxiii. deals with the subject of nebulæ, and includes a useful table of nearly eighty N.G.C. nebulæ which have been shown certainly to be gaseous; the equatorial coordinates of these objects for 1900 are given, and a striking feature of the list is the great preponderance of planetary nebulæ. In the description of the physical characters, the distances, motions and extent of these gaseous masses, various tables of data are interpolated, and should facilitate references to the subject. One of exceptional interest is that in which the determined radial-velocities of thirteen nebulæ are shown. Taking mean values, we see that the extremes of approach and recession are −65 and +44 km. per sec., the values obtained for N.G.C. 6543 and 6790 respectively.

The fixed stars and their spectra and variations are next considered, and the various proposals concerning their classification are discussed; but here we cannot but express regret at the lack of scientific spirit which permeates some of the passages. For example, in describing the classifications, presumably to students and general readers, we find the author stating that the classification proposed by Lockyer, having as a fundamental feature the evolution of the heavenly bodies, is, in his opinion, based on such uncertain premises that he neglects entirely any further reference to its foundation and characteristics. Surely a classification which yet remains to be proved inadequate in the explanation of observed phenomena, and which explains so many of the problems of stellar evolution so simply, should not be so summarily dismissed from what is, presumably, intended as a standard work on the subject. How different is Hale's attitude mentioned above. There, whilst making the reservations which he thinks necessary, he discusses the matter in relation to the most recent work, and shows that one, at least, of the fundamental points in the temperature classification is capable of experimental demonstration.

The remainder of the book is devoted to the discussion of radial velocities, novæ, the changes produced in spectra by variation of the conditions under which the light-source is produced, the several types of stars showing extraordinary spectra, and variable stars. In conclusion, there is a chapter (xxviii.) in which the results obtained from celestial photography are discussed, special attention being paid to the photographs of nebulæ and of the Milky Way.

The volume is illustrated by thirty full-page reproductions of photographs and two hundred and ten figures in the text, and should afford German readers a good general view of the study of astrophysics.

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## *PEKING TO MANDALAY.*[1]

THE great development of the facilities for travel in the interior of China that has taken place in recent years is strikingly brought home to us by the narrative of Mr. Johnston, the magistrate of our little port of Weihaiwei, in North China. Since the days of Marco Polo, who himself travelled from the old capital of China to that of Burma, many European travellers, for instance, Baber, Colquhoun, Gill, and Morrison, have passed through much the same localities and mainly by the same route, but none, perhaps, have traversed the greater part of the ground more swiftly than Mr. Johnston. Leaving Peking on January 13, 1906, by the great new inland railway, built by French and Belgian engineers since the Boxer occupation of Peking in 1900–1, he reached Hankow, on the Yangtse, on January 16, a distance of 759 miles, and the journey could have been done in half the time but for the train running only in the daytime, halting overnight and resuming its journey in the morning. From Hankow, shallow-draught steamers owned by British, Chinese, and Japanese companies proceed up the Yangtse thrice weekly to Ichang, at the entrance to the great gorges of the Upper Yangtse, described by Little and others, a thousand miles from the mouth of that river and in the very heart of China. In one of the Japanese steamers our author made this journey in three or four days from Hankow; and ten days more by "red boat" took him 200 miles through the gorges and up the rapids to Wan-hsien, in the rich province of Ssuch'uan beyond the gorges. Here Mr. Johnston proceeded inland to Tachien-lu, visiting by the way the sacred Mount Omei, to the previous descriptions of which by Baber,[1] Little,[2] and others he adds something, though unfortunately he gives no photographs or sketches of the contour of the mountain.

Mount Omei, which the legends associate with the mythical progenitors of the Chinese race, Fu Hsi and Nu Wo, ascribed to the twenty-ninth century B.C., and who have their caves here, early became a centre of the Buddhists. A temple to Buddha is alleged to have been erected here in the reign of Ming Ti (58–75 A.D.), under whom Buddhism is supposed to have been introduced into China. A remarkable feature of this mountain, and one which has evidently contributed to its sacred repute, is the phenomenon of the *anthelia* locally known as the "Glory of Buddha." From the summit of the mountain the awe-struck pilgrim, standing on the edge of a tremendous precipice, which Baber describes as probably the highest in the world, sees, under favourable atmospheric conditions, several thousand feet below him, floating on a bank of cloud, this beautiful iridescent halo in all the brilliant prismatic colours of the rainbow. It is of the same kind as the spectre of the Brocken, and is to be seen under similar conditions in other parts of the Alps and in the Himalayas. The necessary conditions are said on hearsay by our author, who himself was not so fortunate as to see the spectacle, to be a fairly clear sky and a bank of cloud below; but he omits an equally essential condition, namely, that the sun must be on the opposite side of the spectator to the bank of cloud.

From Mount Omei Mr. Johnston passed to Tachien-lu, the well-known mart and missionary station in western China, and thence down through the wild border country to Burma. The first part of this route lay to the east of the usual track, and led for about a month's march down the valley of the Nya Rong or "Yalung" river to Li-chiang by a road "evidently about the same" as that traversed by M. Bonin in 1895,[3] and by the missionary, Mr. E. Amundsen, in 1898,[4] and crossed by Major H. R. Davies in his exploratory survey of western China. This district and its interesting wild tribes, the Lolo or Man-tzu, and others, are so comparatively unknown that we regret to find so little new about them in this book. The author tells us that his journey "was not undertaken in the special interests of geographical or other science," but to gratify a desire for travel and to acquire some knowledge of the various wild tribes. He gives us, however, little fresh information about the tribes, not even photographs of them that are of any use for ethnological purposes. Indeed, the want of new and more precise observation is the chief defect of the book, and for a travel-book there is far too frequent a tendency to theorise and to inflate the text with discursive and speculative views on the general tenets of Buddhism and on commonplace topics of that religion taken from the well-known works of European writers. So again, when he devotes about ten pages to Mr. Kingsmill's extravagant theory which ascribes to the barbarous Man-tzu tribes of China a descent from "the stock of the Maurya family of north-western India," we think that Mr. Johnston takes too seriously the legends fabricated by Buddhist priests in the countries outside India in order to affiliate themselves to the family of Asoka, the great Buddhist emperor of India. Considerable space, totalling about three pages, is taken up by the introduction of Chinese

[1] "From Peking to Mandalay: A Journey from North China to Burma through Tibetan Ssuch'uan and Yunnan." By R. F. Johnston. Pp. xii+460; with Maps and Illustrations. (London: John Murray, 1908.) Price 15*s*. net.

[1] "Supplementary Papers," Roy. Geog. Soc., vol. i.
[2] "Mount Omi and Beyond." By A. Little.
[3] *Bulletin de la Soc. de Géog.*, 1898, pp. 389 *et seq.*
[4] *Geog. Jour.*, June and November, 1900.